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- Review -

Natural Origin Polymers: Applications as Wound Care Materials

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Wound care is a health industry concern affecting millions worldwide. Recent increase in metabolic disorders such as diabetes comes with elevated risk of wound-based complications. Treatment and management of wounds are difficult practices due to complexity of the wound healing process. Conventional wound dressings and treatment applications only provide limited benefits which are mainly aimed to keep wound protected from external factors. To improve wound care, recent developments make biopolymers to be of high interest and importance to researchers and medical practitioners. Biopolymers are polymers or natural origin produced by living organisms. They are credited to be highly biocompatible and biodegradable. Currently, studies reported biopolymers to exhibit various health beneficial properties such as antimicrobial, anti-inflammatory, hemostatic, cell proliferative and angiogenic activities which are crucial for effective wound management. Several biopolymers, namely chitosan, cellulose, collagen, hyaluronic acid and alginic acid have been already investigated and applied as wound dressing agents. Different derivatives of biopolymers have also been developed by cross-linking with other molecules, grafting with other polymers, and loading with bioactive agents or drugs which showed promising results towards wound healing without any undesired outcome such as scarring and physiological abnormalities. In this review, current applications of common biopolymers in wound treatment industry are highlighted to be a guide for further applications and studies.

Key words : Chitosan, collagen, extracellular matrix, tissue repair, wound care

Background

Part of the skin which is damaged or disrupted in structure and/or function by various factors including but not limited to disease symptoms, infections, external stress, and thermal factors is defined as wound [33]. These complications are often ignored, however, according to recent data published by World Health Organization (WHO), above 5 million people out of 50 million fatally wounded die each year which also leave millions of people in need of urgent treatment for their wounds [99]. As the term wound comprises very different injuries or damages, it is usually classified according to different variables such nature of the wound, occurrence of tissue loss and damaged skin layers. Current market consists of high amount of wound treatment products, some of designed for specific types of wounds, and new ways to treat or care wounds are being developed consistently. Despite the efforts and available options, wound treatment is still a field that needs cost efficient, environmentally friendly, effective and safe healing enhancers to relieve the burden for healthcare services and individuals suffering from different types of wounds [32, 58, 78].

Wound healing

Healing of the skin wounds requires a specific set of processes initiated with the injury via an intricate cascade of biological interactions leading to regeneration of the damaged tissue. Whole process of wound healing is a unique network and interactions among different type of cells (e.g. fibroblasts, keratinocytes, monocytes, macrophages, etc.), extracellular matrix (ECM) components, and cytokines [29]. Normal skin is protected from environmental factors by the protective barrier of epidermis and dermis layers [87]. Wound healing process is concurrently started with damage which breaks the equilibrium state of the protective barrier. Typically, wound healing occurs naturally and follows four or five step process according to different wound healing characterization models (Fig. 1) [12, 86]. These steps overlap each other and consists of hemostasis, inflammation, migra-

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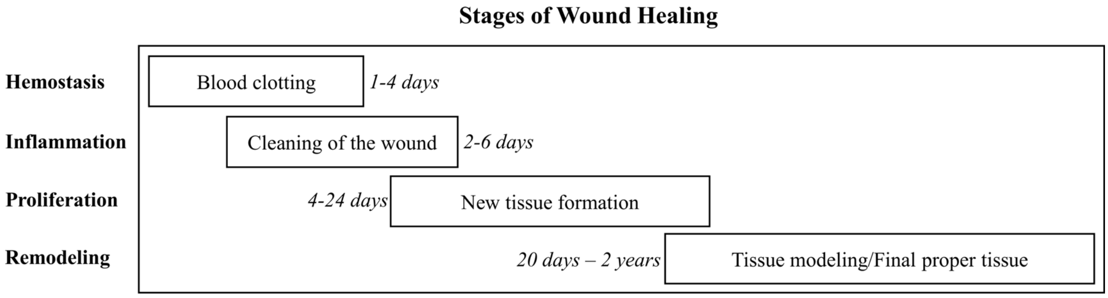

Fig. 1. Stages and approximate time span of wound healing process.

tion/proliferation, and remodeling (maturation) [12, 54]. Rate of these steps, hence the wound healing period, depend on several contributing factors, i.e. type of the wound (acute, chronic, superficial, etc.) and the status of individual during healing process (immunological and hormonal well-being) [31].

First step of the wound healing process is called hemostasis and targets to form blood clots with cross-linked fibrin protein as a first barrier against external factors, blood loss and to retain moisture [12]. Repairing the damage starts promptly after the injury and follows a strictly regulated closely linked biochemical signaling cascade at each step. First step, hemostasis, starts with the accumulation of the thrombocyte platelets at the site of the injury to form the clot using fibrin protein which cross-links with itself and act as a mesh barrier [50]. This barrier is mainly composed of fibrin along with some blood cells and accumulated thrombocytes. Conventional wound treatment with traditional products such as sponges, bandages, and gauze dressings find their use in this first step of wound healing and act as extra barrier that prevent bleeding and keep the wound moist for further steps to take place seamlessly [21]. Inflammation is the next step overlapping the fibrin mesh clot formation by release of pro-inflammatory cytokines from cells in injured tissue. Inflammatory response following the release of cytokines is the movement of leukocytes and monocytes to the injury site and clean the area of bacteria and remove the debris [11, 64]. In the inflammation step, growth factors are also secreted by activated monocytes in order to initiate the next overlapping wound healing step, migration/proliferation [49]. In this stage angiogenesis occurs simultaneously with granulating tissue formation, ECM component synthesis and deposition, and epithelization and contraction of the injured area. During granulating tissue formation new fibroblasts mature and secrete collagen and fibronectin as the first steps of forming new ECM. New vessels are formed by angiogenesis and reepithelization of the epidermis layer is observed as the epithelial cells migrate and place themselves on top of each other, creating a cover for the newly organized tissue [28]. This stage is also responsible for scars and esthetical abnormalities due to excess formation of the granulating tissue and in return more than necessary collagen synthesis [23, 61]. Also, during this stage and the overlapping last stage of remodeling wounded tissue regains its functional state along anatomical and physiological properties via several activated pathways such Wnt/β-catenin, MAPK, and PI3/Akt [88, 105, 108]. Last stage of the wound healing process is the remodeling the newly formed tissue. This step overlaps the synthesis of the collagen as the newly produced collagen is amassed randomly. Remodeling of the new tissue includes the degradation of the irregularly deposited collagen and reorganization of the collagen fibrils regularly in bundles along the required lines [86].

Complications and unwanted esthetical outcomes are common during wound healing if any of the overlapping steps is altered in some way. As the wound healing process is complex, closely linked and tightly regulated, a comprehensive care is of utmost importance during the healing without small to none alterations in patients' daily life.

Wound care agents

Several applications are available to provide the care and treatment effects that wound requires, however with their limitations to overcome the challenges of complex wound healing process. Failure to deliver adequate care may result in serious undesirable aftereffects such as loss of function, scars, chronic wounds, and fibrosis [27, 31, 102]. These applications, called wound dressing, target the injured area as they cover the wound to serve as a scaffold for new cells and ECM to form upon, and produced from suitable materials which are biodegradable, allowing oxygen and vapor permeation while blocking the external impacts and internal leaks [19]. One other important factor to be taken into consideration is the prevention of the infection of the wounded area to hasten and smooth the healing process. Several natural and synthetic materials have been developed by collaborative researches of different fields such as biochemistry, textile, and organic material engineering [85, 91]. These promoted wound dressing materials have been shown to possess promising beneficial effects towards the uninterrupted and complication-free wound healing. Owing to recent improvements in skin tissue engineering and wound healing studies, bioactive substances have gained much attention and acclaim. They have been positively influential in intrinsic and dynamic healing process through direct interaction with responsible pathways or building blocks of the new ECM [22, 47]. Natural products have been studied in detail for decades and suggested to exhibit numerous health beneficial properties that can be utilized as wound treatment agents. Due to their bioactivities, natural product-based wound care products can interact with inflammation, proliferation and remodeling steps of healing [10, 85]. As previous studies showed, natural bioactive substances can enhance or intervene cellular signaling pathways to increase the rate and efficacy of differentiation, specialization, and function of significant cell types of wound healing, fibroblasts, macrophages, and keratinocytes [37, 68, 75, 94]. Apart from intracellular interaction, bioactive substances can also regulate inflammatory response, eliminate infectious threats, and aid the ECM building. Among the beneficial materials that have been used in wound care, polymers from different sources are widely employed with a broad scope as polymers have been exploited as durable and highly biocompatible materials with ideal characteristics beneficial to crucial wound healing steps including cell proliferation, ECM organization and antimicrobial action [10, 45]. In this context, current review targets and underlines the current trends in using natural origin biopolymers as wound dressing and treatment materials.

Natural origin biopolymers in wound treatment

Polymers in wound dressing

Polymers are big organic molecules formed from smaller repeating units called monomers. Polymers have been used in different fields of health care system for a long time. Hemorrhage prevention is one of those fields where biopolymers are mainly employed as most of natural polymers present favorable combination of beneficial properties, i.e. biodegradable, non-inflammatory and non-irritant [60, 65].

Some synthetic polymers, that are polymers created through chemical reactions in laboratory conditions, have been broadly utilized. Among them polylactic acid and polyglycolic acid are part of implant development studies and skin tissue engineering while in bone tissue engineering hydroxyapatite is widely exploited as hemostatic agent against bone sternums [6, 30, 67, 97]. Liquid and glycol wound sealants also largely contain synthetic polymers. Aside from synthetic polymers, proteins and polysaccharides are also polymers of natural origin that are heavily used to prevent bleeding when applied as wound dressing.

Natural biopolymers are polymers that are built in living organisms using organic molecules as their building blocks/monomers such as amino acids and monosaccharides (Fig. 2).

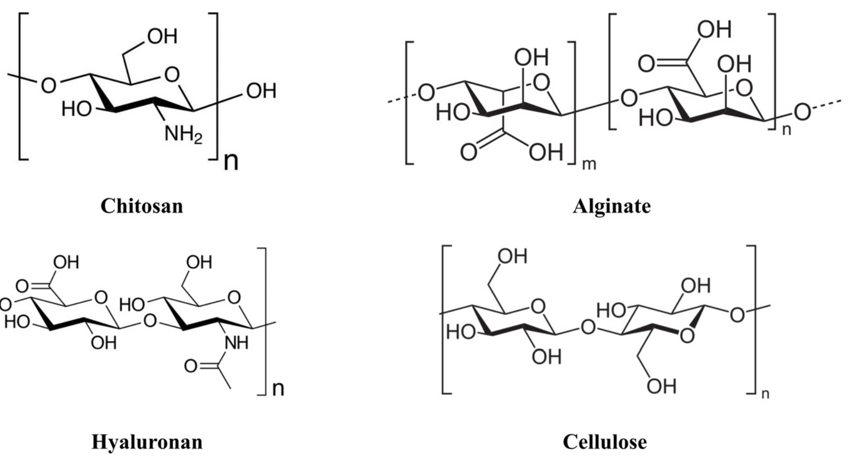

Fig. 2. Chemical structures of biopolymers used in wound dressings.

Broad range of sources varying from plants to bacteria have been utilized to obtain different biopolymers with different advantages to be put use in wound care products [2, 65]. Fibrinogen, collagen, albumin, and gelatin are proteins known for their hemostatic properties along commonly applied polysaccharides such as chitosan, cellulose, and poly-N-acetyl glucosamine [79, 80, 104]. Due to their natural origin, natural biopolymer wound care agents are extensively biodegradable and biocompatible which makes them favorable over synthetic polymers. They have been applied on wounds in different forms varying from sponges to liquids. Natural polymers also have been observed to be reabsorbed readily by the body without causing inflammatory response when applied on injured areas. Coupling these features with hydrophilicity and their supporting presence during new tissue formation has generated much attention towards the use of natural polymers in skin tissue engineering, especially in wound care and treatment [10, 15].

Chitosan

Chitin is naturally abundant and simple β-(1→4) glycan composed of 2-acetoamido-2-deoxy-d-glucopyranose units. It is the major constituent of shells of arthropods such as crabs, shrimps, lobsters, insects, and it also is produced extracellularly by fungi and some brown alga. Chitin is a by-product or a waste from crab, shrimp, and crawfish processing industries and a highly water-insoluble compound. Chitosan is a functional and basic linear polysaccharide prepared by N-deacetylation of chitin in the presence of alkaline. Chitin and chitosan are known to exhibit antitumor, hypocholesterolemic, and antihypertensive activity [71, 107]. The main motive for the development of new applications for chitosan lies in the fact that it is a very abundant polysaccharide, as well as nontoxic and biodegradable. Among all reported biologically active properties of chitosan, hemostasis stimulation and tissue generation acceleration made it a widely chosen polymer agent to be introduced in wound treatment [3, 14]. To add its already advantageous characteristics, its ability to prevent bacterial and fungal growth is crucial for efficient wound healing [18]. In addition to antimicrobial activities, chitosan is also reported to promote cell proliferation along fibroblast activation at a degree which is directly correlated with chitosan deacetylation levels [63, 95].

Initially chitosan has been used similar to that of other polymers in wound treatment as a dressing material to serve as a scaffold for new tissue generation and as hydrogels for stimulate the wound healing [3]. Chitosan-based dressings provided the necessary conditions for efficient wound care; a moist environment, protected from secondary infections and hastened tissue regeneration. Using sheets of N-carboxybutyl chitosan on surgery wounds of plastic surgery patients expressed faster and more organized healing with minimal anomaly compared to that of traditional dressings [9]. Other studies by Ishihara et al. [42, 43] revealed that application of chitosan hydrogels notably enhanced the wound healing and contraction as well as accelerated the closure of incisions in vivo. Stone et al. [89] demonstrated that skin grafting splits returned to normal color earlier with chitosan dressings compared to conventional ones. Chitosan also advanced the reepithelization, angiogenesis and nerve regeneration. Further, mixing chitosan with other polymers produced promising results towards better wound management. Particularly, blending chitosan with polyethylene glycol to form a wound treatment film expressed encouraging results [35]. Wounds applied with chitosan-polyethylene glycol film showed stimulated protein adsorption, increased cell proliferation and ECM formation along with sterile conditions free of any secondary infection. Photo-crosslinkable chitosan hydrogels bound with fibroblast growth factor-2 (bFGF) and epidermal growth factor (EGF) were shown to significantly stimulate wound healing through wound contraction and reepithelization in healing-impaired mice and rats with burn wounds, respectively [4, 72]. In another study reported by Paul and Sharma [74], a wound dressing containing a combination of antibiotics and analgesics with chitosan, alginate and polyethylene glycol base helped to maintain chronic non-healing ulcers on human subjects and showed beneficial effects towards faster healing and control of infection.

Owing to its cationic characteristics, chitosan is very suitable to be used as a drug carrier polymer. This nature of chitosan was also employed in studies for better wound treatment. Collagen synthesis was increased in both in vitro and in vivo evaluations when the wounds were treated with polyethylene glycol-grafted chitosan composite film loaded with curcumin [56]. Ong et al. [73] showed that chitosan wound dressings impregnated with polyphosphate and silver exhibited significant hemostatic and anti-infective effects on wounds, particularly against *Staphylococcus* and *Pseudomonas* sp. Other studies loaded chitosan-based wound dressing materials with cerium oxide [41], taurine [20], and neuropeptide neurotensin [69] to obtain downregulated inflammatory signaling, increased tissue regeneration, and stimulated fibroblast migration and collagen deposition, respectively.

Overall, studies showed that chitosan acts as suitable matrix for new tissue growth while activating macrophages, fibroblast migration and proper organization of ECM. Also, chitosan was reported to act as a notable hemostatic agent with pain reducing properties. N-Acetylglucosamine, monomer of chitosan, is able to stimulate fibroblast proliferation and aids to orderly clustered collagen deposition when released by depolymerization of chitosan wound dressing films, foams or hydrogels [9].

Alginate

Alginate, a predominantly brown alga sourced polysaccharide, is comprised of (1-4)-linked β-D-mannuronate and α-L-guluronate monomers. Alginate is quite effective in absorbing the wound excretion and preventing undesired odor and pain [44]. Alginate dressings turn into gels through absorbing wound excretions via ionic exchange of alginate calcium and wound, or blood, sodium [93]. As expected, alginate also provides necessities for a proper wound treatment such as moist environment, limiting infection and external interference, and stimulating tissue regeneration. Also, monocytes were shown to produce elevated levels of IL-6 and TNF-α, which are important cytokines for wound healing, following alginate introduction [1, 103]. Cell adhesiveness to the alginate is the main drawback of alginate use in wound treatment. This lack of scaffolding support for new ECM formation was overcome through the addition of peptide sequences in order to obtain cell-interactive alginates [5, 51]. Cell-interactive alginates were observed to mimic ECM features to accelerate the wound healing process by stimulated cellular response to alginate. In addition, modifications on alginate was regarded to be more attainable compared to some other polymers which leaded to development of alginate-based combined wound treatment agents [52]. Improved wound healing results were achieved by blending alginate with curcumin or silver, silk fibroin, and chitosan [55, 83, 98]. Hydrogen films formed by sodium alginate blended with Aloe vera prior to UV-crosslinking showed favorable wound protection along protection from UV and light-induced damages [76]. Promising results were observed on wounds of healing-impaired mice when a hydrogel blend of alginate, chitosan, and fucoidan was applied [70]. In another study by Xie et al. [101], chitosan-collagen-alginate composite dressing expressed increased fibroblast migration, and upregulated expression of bFGF, EGF. Rats treated with composite dressing showed accelerated and smooth wound healing compared to rats treated with gauze or chitosan-only dressings. Alginate-chitosan composite dressings were also tested for their ability to be carriers for beneficial molecules. Hu et al. [39] reported that amorphous hydrogels based on chitosan/alginate composite impregnated by EGF showed significantly better healing outcomes on rat wounds. Likewise, alginate was also shown to be feasible for mineral crosslink, particularly zinc. Crosslinked zinc-sodium alginate polyacrylamide hydrogels showed superior antibacterial and wound care properties [109].

Collagen

Collagen is the most abundant protein in mammals as it is the dominant component of the connective tissue. It is formed by repeating amino acids bound by peptide bonds and constitute the substantial part of ECM. Although there are more than 20 types of collagen, human body consists of mainly type I collagen followed by type II and III which comprise less than 10% of total collagen [7]. Collagen is degraded into small fragments, particularly gelatin, during the inflammatory response to an injury. Collagen degradation is followed by macrophage migration to injured area and fibroblast proliferation in order to form the new tissue. These processes are initiated by the specific cleaved parts (Arg-Gly-Asp) of the collagen, hence, collagen degradation is one of the most important parts of the wound healing [8]. In a similar fashion, presence of gelatin induces keratinocytes to lose cell adhesion and gain their mobility, therefore stimulating migration for tissue regeneration [77]. However, deteriorated regulation of collagen production versus the collagen cleavage results in unsuccessful healing, undesired outcomes, or chronic wounds. When the collagen degradation is not coupled with sufficient collagen synthesis due to dysregulated enzymatic activity (especially MMPs), newly formed collagens are steadily cleaved keeping wound healing process in the inflammatory step [82]. This problem was shown to be eliminated via external collagen supplement. Collagen-based wound dressings play important role in this context, providing the excess collagen by means of inert collagen and gelatin which in turn hinder the MMP activity and further the wound healing process from inflammatory step to proliferation [13]. Structural modification (cross-linking, blending, loading, etc.) of collagen supplied by wound dressings can help to maintain the degradation rates, hence, accelerating the wound healing.

Studies exhibited that wound healing action of collagen can be significantly improved by modifications such as depolymerization, binding with anti-inflammatory and antibacterial molecules, etc. Use of exogenous collagen for skin repair by remodeling the collagen fibrils with electrospinning and crosslinking with bioactive ingredients showed improved wound healing benefits. Rho et al. [81] suggested that mimicking the ECM collagen could be achieved by electrospinning collagen nanofibers coated with laminin. Using electrospun collagen-laminin composite expressed improvements in cell adhesion and proliferation during tissue repair. Diabetic wounds improved when collagen linked with quercetin was introduced, due to remarkable reactive oxygen species scavenging [17]. A similar study also suggested that curcumin loaded collagen matrix showed healing properties on diabetic wounds with improved reepithelization [46]. Electrospinning collagen fibrils in a similar way to that of natural skin also showed increased wound healing efficiency for collagen-based wound treatment products. Sun et al. [90] reported that producing nanofibrous collagen scaffolds electrospun in a basket weave pattern which resembles the collagen in native skin, enhanced wound healing in diabetic wounds of rats.

Hyaluronan

Hyaluronan is a biopolymer found in human body commonly throughout connective, epithelial, and neural tissues. It is made of disaccharide repeats; D-glucuronic acid and N-acetyl-D-glucosamine linked by alternating glycosidic bonds of β-1,4 and β-1,3. Present in epithelial tissue, the role of hyaluronan in efficient wound healing is critical. Migration/proliferation and remodeling stages of wound healing are stimulated by the presence of hyaluronan [16]. When degraded, the cleaved parts of hyaluronan was showed to exhibit angiogenesis enhancing properties [25]. Also, proliferation of keratinocytes was enhanced following degradation of hyaluronan as the degradation products bound to CD44 receptors [26].

In the same way to collagen supplement, providing exogenous hyaluronan during the healing process of an injury expressed beneficial effects, although hyaluronan is natively present in skin tissue. Following post-injury hyaluronan introduction, reduced scarring was observed with healthy tissue repair. Hu et al. [38] developed a hyaluronan scaffold which downregulated the TGF-β1 expression and provided an environment for promoted wound healing. Huang et al. [40] suggested that treating non-healing wounds with hyaluronan-chitosan hydrogels loaded with vancomycin carrying poly(lactic-co-glycolic acid) microspheres significantly reduced microbial load of the injured area and stimulated the proliferation of endothelial cells. Likewise, hyaluronan-pullulan composite wound films improved wound healing by means of stimulated hemostasis and improved non-enzymatic debridement [53]. Similar results were reported with wound healing studies using hyaluronan linked with active molecules or other polymers. Hyaluronan conjugated with chitosan and edaravone exhibited anti-inflammatory effects during wound healing both in vitro and in vivo [92] while hyaluronic acid, bisphosphonate and silver conjugation resulted in promoted healing with minimal microbial load in vivo [84]. Also, a randomized clinical trial conducted by Yildirim et al. [106] reported that topically applied hyaluronan presented improved palatal epithelial wound healing with reduced pain.

Cellulose

Cellulose is a biopolymer containing repeating β-d-glucose monomers linked with β-1, 4-glycosidic bonds and present in cell walls of plant and bacteria. The porous structure of cellulose resembles the ECM of human skin and is suggested to be beneficial as a scaffold for tissue generation [36]. Due to its chemical structure, cellulose is mainly used to keep the wounds moist and remove the wound excretions via absorbing the dead tissue molecules and fibers. Keeping wound moist is of high importance to wound healing, as the moist environment is needed for supplying growth factors, migrating macrophages and proliferating fibroblasts [48]. Other than wound protection activities cellulose does not exhibit any beneficial effects in healing process. However, modification of cellulose by linking bioactive agents and therapeutic molecules or conjugating with other polymers generated promising results for cellulose to be used as base for wound treatment products. Blending cellulose with antimicrobials such as silver nanoparticles and myostatin resulted in wound dressing materials that show notable antibacterial effects against *E. coli* and *S. aureus* when applied on open wounds [62, 100]. Reepithelization of burn wounds was achieved by wound dressing hydrogels produced from cellulose UV cross-linked with acylic acid [66]. Similar results were observed with bacteria-derived cellulose membrane conjugated with chitosan [57]. Wound dressings with antibacterial and anti-inflammatory activities that can accelerate tissue regeneration were obtained by conjugating cellulose with tungsten oxide and polydopamine [24, 59].

Some cellulose modifications such as creating nanoscale fibrillary, oxidized, and methylated cellulose produced promising results. Nano-fibrillar cellulose showed improved healing on skin graft donor wounds [34] while methylated and oxidized cellulose stimulated critical cellular responses such as cell migration and proliferation in injured area with improved hemostasis [96].

Cellulose provide perfect environment for keeping wound moist and protected and with efficiently modifiable structure cellulose-based wound treatment agents and tissue repair applications can be developed with improved benefits.

Summary and future trends

The biophysical process of wound healing is quite complex and regulated with diverse signaling and physiochemical pathways. The desirable outcome of wound healing with minimal scar development, healthy tissue regeneration and organized ECM deposition is closely linked to the interactions between transcription factors, extracellular stimuli and cellular signaling. Natural polymers provide unmatched biodegradability, promising bioactivities and cost-efficient sourcing with minimal to none side effects to development of wound treatment applications. Chitosan, alginate, hyaluronan, collagen and cellulose are main biopolymers that are currently main actors of wound treatment and skin engineering studies and industry. Although current market comprises of various wound treatment options based on natural biopolymers each providing specific advantages towards different types of wounds, improvements are needed as the attaining perfect healing is a condition yet to be achieved. Biological roles and drawbacks of the reviewed polymers summarized in Table 1. Future wound dressings and tissue repair agents are needed to come with improved abilities to provide antimicrobial, hemostatic, anti-inflammatory, ECM mimicking properties, all in a suitable environment where cellular responses are also stimulated and regulated. Future studies to understand the chemical, mechanical and biophysical aspects of biopolymers will advance the modifications of biopolymers to better suit the wound care needs. Also, recent developments in nanotechnology and bioengineering will enable loading biopolymers with growth factors, drugs, or bioresponsive molecules for enhancing tissue repair in nano-level with maximum cellular interaction. Developments in electrospinning and 3D bio-printing will also enable to produce scaffolds that mimic ECM in an elevated level to provide the perfect microenvironment for tissue formation, cell adhesion, skin repair, etc. Furthermore, recent technologies pave the way for discoveries that will yield knowledge and know-how to produce efficient cell-based therapies and tissue engineering to obtain ECM substitutes. With technological improvements

Table 1. Sources, biological roles and possible drawbacks of natural polymer wound dressings

Wound dressing material	Source	Role in wound healing	Possible disadvantages
Chitosan	Crustacean exoskeleton, fungi cell wall	Migration and proliferation inducement of fibroblast and keratinocytes, good antimicrobial effect	Molecular weight-dependent negative effects on cell proliferation
Alginate	Brown algae	Stimulation of monocytes, migration and proliferation inducement of fibroblasts	Adherence to the wound area, unpleasant odor, residue in wound area
Collagen	Animal (bovine, porcine, etc.)	Stimulation of ECM component production and secretion, fibroblast proliferation inducement	Unpleasant odor, cost, requirement of a second dressing
Hyaluronan	Animal (combs, cartilage, etc.)	Anti-inflammatory effect, Stimulation of fibroblast migration	Poor stability, semi-permeable, low bacterial barrier
Cellulose	Plant cell wall, bacteria	Moisture retention, exudate absorption	Poor antimicrobial activity, needs often changes due to dryness

in bioengineering and advantageous structures of biopolymers, wound treatment applications are also improving significantly to obtain accelerated wound healing for both acute and chronic wounds with none undesirable outcome.

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상처 치료는 전세계 인류에 영향을 미치는 보건 산업계의 관심사다. 당뇨병과 같은 대사증후군 유병률 증가로 상처에 의한 합병증의 위험이 높아지고 상처치유의 복잡함 때문에 상처의 치료와 관리가 어렵다. 전통적 상처 드레싱은 제한된 보호기능을 제공하며, 상처 드레싱의 치료 능력을 향상시키기 위해 생체고분자 기반의 드레싱들이 개발되고있다. 생체고분자는 생분해성이 뛰어나고 생체적합성이 좋으며 효과적인 상처 관리에 중요한 항균, 항염증, 지혈, 세포증식, 혈관성 활동 등 다양한 효과가 있다. 키토산, 셀룰로오스, 콜라겐, 히알루론산, 알긴산 등의 여러 생체고분자가 이미 상처치유제로 활용되고 있으며 생체고분자를 다른 고분자, 생체활성 분자 및 약물과 결합하여 생리학적 문제 없이 흉터를 최소화하는 새로운 상처 드레싱이 개발되고 있다. 본 논문에서는, 향후의 연구와 활용을 위한 현재의 생체고분자의 상처처리에 대해 알아보았다.